

ARRHYTHMIA DETECTION USING ECG FEATURE EXTRACTION AND WAVELET TRANSFORM

CHETAN S. PATIL¹ & SHAILAJA GAIKWAD²

¹Department of Electronics and Telecommunication Engineering Terna Engineering College,

Nerul, Navi Mumbai, Maharashtra, India

²Department of Electronics Engineering, Terna Engineering College, Nerul, Navi Mumbai, Maharashtra, India

ABSTRACT

Cardiac Arrhythmia is the most common cause of death. These abnormalities of heart may cause sudden cardiac arrest or cause damage of heart. The early detection of arrhythmia is very important for the cardiac patients. Electrocardiogram (ECG) feature extraction system has been developed and evaluated based on the multi-resolution wavelet transform. ECG feature extraction plays a significant role in diagnosing most of the cardiac disease. One cardiac cycle in an ECG signal consist of the P-QRS-T waves. This feature extraction scheme determines the amplitudes and interval in the ECG signal for subsequent analysis. The amplitude and interval of P-QRS-T segment determine the function of heart. The ECG signal will be de-noised by removing the corresponding wavelet coefficients at higher scales. Then, QRS complexes are detected and each complex is used to locate the peaks of the individual waves, R-R interval which are present in one cardiac cycle and evaluated the algorithm on MIT-BIH Database, the manually annotated database, for validation purpose.

KEYWORDS: Cardiac Arrhythmia, P-QRS-T Segment, MIT-BIH Database

INTRODUCTION

Arrhythmias are problems that affect the electrical system of the heart muscle, producing abnormal heart rhythms. ECG interpretation is one of the most important upcoming areas and widely used clinical tool. Cardiac Arrhythmias are the most common causes of death; it is an abnormal rate of muscle contractions in the heart ^[1]. These abnormalities of heart may cause sudden cardiac arrest or cause damage to heart. The primary aim of this paper is QRS detection of Electrocardiogram waveforms and abnormalities and hence facilitating early detection of cardiac problems ^[3]. Arrhythmia Detection through ECG Feature Extraction using Wavelet Analysis 442 ^[2]. In this paper, the Electrocardiogram (ECG) of a normal healthy human is compared with that of a patient who may suffer from Cardiac Arrhythmia. Development purposes, the MIT-BIH database of ECG waveforms are used for test data. Cardiac arrhythmias are a common accompaniment of a variety of cardiac diseases.

Heart

The heart is one of the most important organs in the entire human body. This task of supplying oxygen is done by cardiovascular systems. Blood is the body's medium for transporting oxygen to the organs. The heart, which is a sort of muscular pump, supplies blood throughout the body. A complex set of arteries, vessels and capillaries connect the heart to the entire body shown in figure 1^[4].

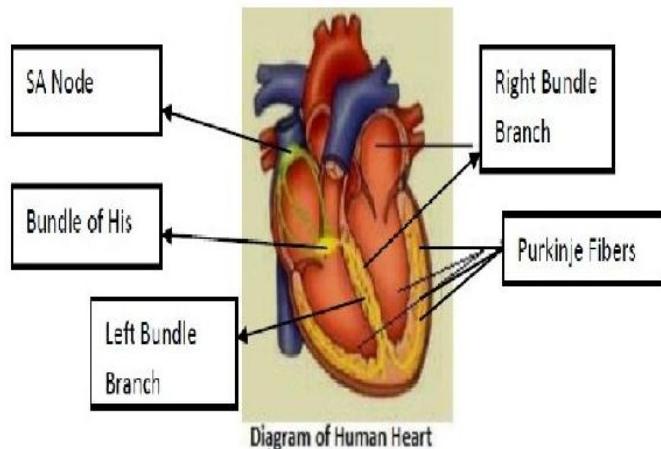


Figure 1: Conduction System Structure of Heart

The walls of the heart are made up of three layers, while the cavity is divided into four parts. There are two upper chambers, called the right and left atria, and two lower chambers, called the right and left ventricles. The purpose of the Atria, is receive blood from the body, the right atrium receives oxygen-devoid blood from the body and the left atrium receives oxygen-rich blood from the lungs. The heart is controlled by a very precise electrical system [4]. This system regulates the mechanical pumping action of the heart so that the entire cardiovascular system can function properly. If a problem occurs in the electrical systems of the heart, it can have devastating effects for the entire body.

Electro Car Diagram (ECG)

Fundamentally an ECG is a graphic representation of the electrical activity of the heart muscle. When cardiac muscle cells are excited, they produce an electrical impulse lasting approximately 300 ms. This is followed shortly by mechanical contraction of the muscle cells [6]. The electrocardiographic deflections are termed P, QRS complex, T and U as in Figure 2. The P wave represents atrial activation; QRS complex represents ventricular activation or depolarization. The T wave represents ventricular recovery or re-polarization and the S-T segment, the T wave and the U wave together represent the total duration of ventricular recovery [8].

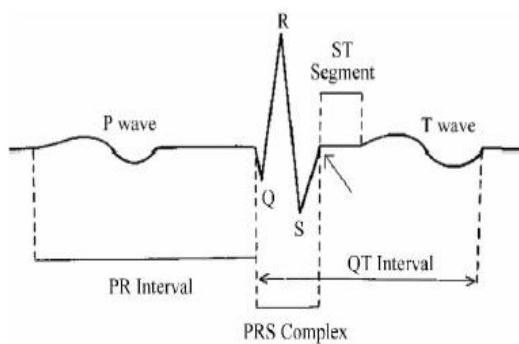


Figure 2: Representation of the Basic Electro Cardiograph Deflections

Arrhythmia

Disturbance in the regular rhythmic activity of the heart. Cardiac arrhythmia may be caused by irregular firing patterns from the SA node, abnormal activity from other parts of the heart. Table 1. Presents deviations from the normal values of ECG features (segments and intervals) and Respective arrhythmia type Arrhythmia Detection through ECG Feature Extraction using Wavelet Analysis [7].

Table 1: Different Abnormalities and Corresponding Arrhythmia

RR interval longer	Bradycardia
RR interval shorter	Tachycardia
Long PR interval	First degree heart block
ST segment elevated	Myocardial infarction
ST segment short(absent)	Hypercalcemia
Wide QRS	Premature ventricular contraction
Absence of P wave (AVR)	Atrial fibrillation, Idioventricular rhythm
Inverted T wave	Coronary ischemia
Long QT interval	Nocturnal hypoglycemia
More P waves than QRS complex	Second and third degree AV block
Tall or tent shaped T wave	Hyperkalemia

LITERATURE SURVEY

There are different techniques used for classification of arrhythmias such as:, [1] Dingfeital. used the autoregressive modeling to classify normal sinus rhythm (NSR) and five types of cardiac arrhythmias which are atrial premature contraction (APC), Premature ventricular contraction (PVC), ventricular tachycardia (VT), super ventricular tachycardia (SVT), and ventricular fibrillation (VF). In this algorithm, the autoregressive (AR) modeling was performed on the ECG data and the autoregressive (AR) coefficients were extracted using Burg's algorithm, these coefficients were classified by a generalized linear model (GLM). The accuracy of this algorithm in the detection of NSR, APC, PVC, SVT, VT, and VF were 93.2% to 100%. [2] Szi-Wen Chen used the Prony modeling method to discriminate between ventricular fibrillation (VF), ventricular tachycardia (VT) and super ventricular tachycardia (SVT). In this algorithm, two features are extracted from the total least squares (TLS)-based Prony model which are dubbed energy fractional factor (EFF) and predominant frequency (PP). The EFF is used to discriminate the SVT from VF and VT, and then the PP is used to discriminate VF from VT. The accuracy of detecting SVT, VF, and VT were 95.24%, 96.00%, and 97.78% respectively by using this algorithm., [3] Thakoretal. used the complexity measure method to discriminate between Sinus rhythm (SR), ventricular tachycardia (VT) and ventricular fibrillation (VF). The authors presented a fast method for detecting the previous types of arrhythmias by getting the complexity measure suggested by [4] Lempel and Ziv (1976). In this study for a specific window length, the method firstly generates a string of zeros and ones by comparing the ECG data to a suitable threshold then the complexity measure can be obtained from the string of zeros and ones by comparison and accumulation.

The accuracy of the detection of SR, VT, and VF is 100% when the window length is 7 seconds.

Problem Definition

It is proposed to develop ECG feature extraction system and evaluation based on the multi resolution wavelet transform and also to build a computer aided diagnosis system to classify the different abnormalities and corresponding arrhythmia by analyzing the ECG signal using PCA technique.

Roposed Methodology

ECG data is preprocessed by wavelet transform. Wavelet Transform. Is used for de noising purpose. After that PCA will be use as a feature extraction.

Wavelet Transform

The major advantage of DWT is that it provides good time resolution at high frequency and better frequency resolution at low frequency. One very important application is the ability to compute and manipulate data in compressed parameters, which are often called features. Thus, the ECG signal, consisting of many data points, can be compressed into a few parameters. These parameters characterize the behavior of the ECG signal. Matlab and its wavelet toolbox were used for ECG Signal processing and Analysis. In order to extract useful information from the ECG signal, the raw ECG signal

should be processed. The ECG signals have been downloaded from MIT-BIH data base and with time length of 30 minutes and sample frequencies of 300 Hz, have been utilized in this work. ECG signal processing can be roughly divided into two stages by functionality: Preprocessing and Feature Extraction as shown figure 3 the purpose of the feature extraction process is to select and retain relevant information from original signal, using Discrete Wavelet Transform. The preprocessing stage removes or suppresses noise from the raw ECG signal [5].

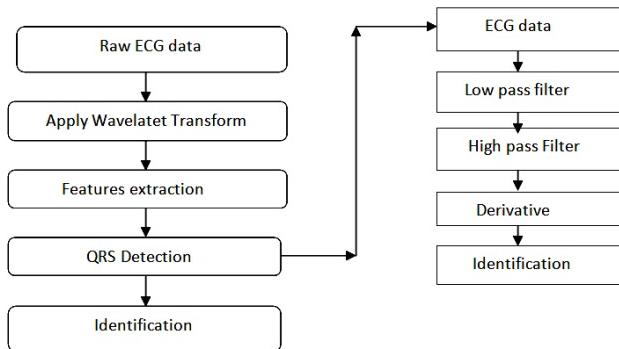


Figure 3: Structure of ECG Signal Processing

The QRS complex is the most important complex in the ECG. The duration and amplitude are to be measure as accurate as possible. There are two methods to highlight the QRS complex. These are the Pan-Tompkins algorithm and the derivation-based method.

The major advantage of Wavelet transform is that it provides good time resolution at high frequency and better frequency resolution at low frequency. One very important application is the ability to compute and manipulate data in compressed parameters, which are often called features. Thus, the ECG signal, consisting of many data points, can be compressed into a few parameters. These parameters characterize the behavior of the ECG signal. In order to extract useful information from the ECG signal, the raw ECG signal should be processed. ECG signal processing can be roughly divided into two stages by functionality: Preprocessing and Feature Extraction as shown algorithm The purpose of the feature extraction process is to select and retain relevant information from original signal, using Discrete Wavelet Transform. The preprocessing stage removes or suppresses noise from the raw ECG signal. . The amplitude and interval of P-QRS-T sequent determine function of heart. Hence by analyzing P-QRS-T waveform we can detect the different abnormalities and corresponding arrhythmia.

CONCLUSIONS

Thus by developing ECG feature extraction system using multi resolution wavelet transform and PCA technique will be possible to detect the particular type of arrhythmia.

Two types of features were extracted from the ECG signals to make two different systems which are Fourier Transform (FFT) based features Extraction and Principal Component Analysis (PCA) based features Extraction.

We compare the results between the two systems to get which one of them is the best. For each system, we try different number of features to get the best number of features that give the highest accuracy of the system.

Principal components as inputs to the classifier and get the accuracy of each of them and we found the highest accuracy occur when we used the first 15 components.

The highest accuracy of the system that depends on the Fourier Transform (FFT) as features equal 90.625 % the highest accuracy of the system that depends on the Principal Component Analysis (PCA) as features equal 92.7083 %

From the previous results, we conclude that the system of classification that depends on the Principal Component Analysis (PCA) as a feature is better than Fast Fourier Transform (FFT).

RESULTS

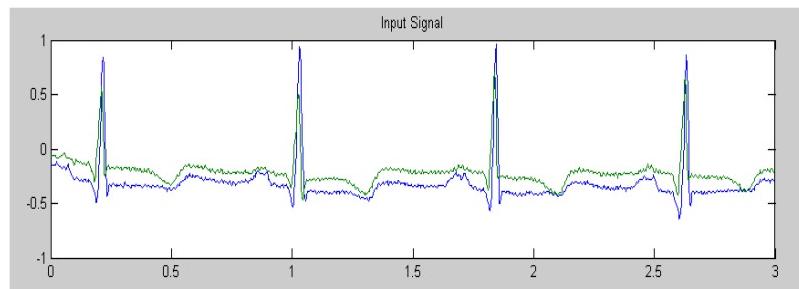


Figure 4: ECG INPUT Signal

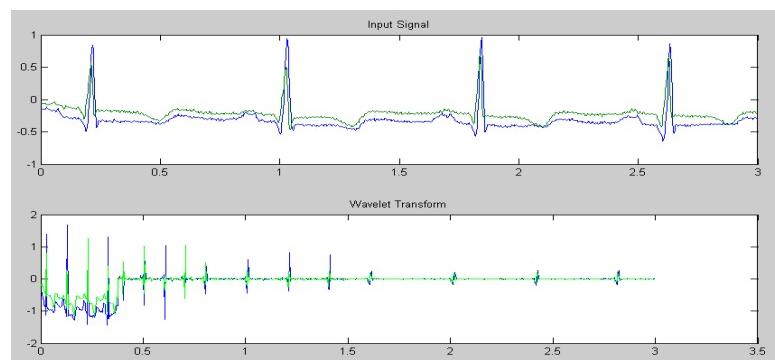


Figure 5: Result after Wavelet Transform

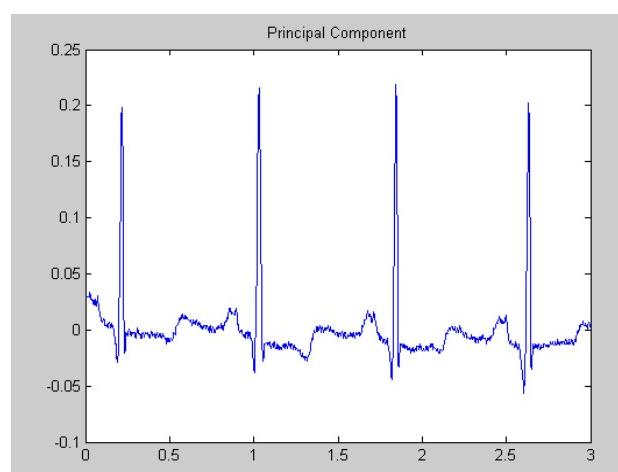


Figure 6: Result after PCA

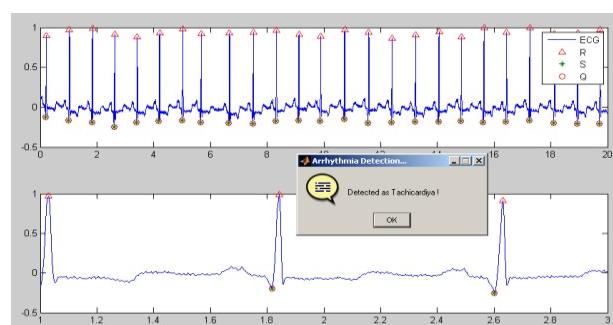


Figure 7: Result after QRS Detection

REFERENCES

1. J. Pan and W.J. Tompkins, "A real-time QRS detection algorithm", IEEE Trans. Biomed. Eng., vol. 32, pp. 230–236, 1985.
2. V.X. Afonso, W.J. Tompkins, T.Q. Nguyen, and S. Luo, "ECG beat detection using filter banks", IEEE Trans. Biomed. Eng., vol. 46, pp.192–202, 1999.
3. "The MIT-BIH Arrhythmia Database," [http://physionet.ph.biu.ac.il/physiobank/database /mitdb/](http://physionet.ph.biu.ac.il/physiobank/database/mitdb/)
4. W.P. Holsinger, K.M. Kempner, and M.H. Miller, "A QRS preprocessor based on digital differentiation", IEEE Trans. Biomed. Eng., vol. 18, pp. 121–217, May 1971.
5. M. Bahoura, M. Hassani, and M. Hubin, "DSP implementation of wavelet transform for real time ECG wave forms detection and heart rate analysis", Comput. Methods Progrms Biomed. vol. 52, no. 1, pp. 35–44, 1997.
6. S. K. Zhou, J.-T. Wang and J.-R. Xu, "The real-time detection of QR Scomplex using the envelop of ECG", in Proc. 10th Annu. Int. Conf. IEEE Engineering in Medicine and Biology Society, New Orleans, LA, 1988, p. 38.
7. R. V. Andreao, B. Dorizzi, and J. Boudy, "ECG signal analysis through hidden Markov models", IEEE Transactions on Biomedical Engineering, vol. 53, no. 8, pp. 1541–1549, 2006.[13] B.U. Kohler, C. Hennig, and R. Orglmeister, "The principles of software QRS detection", Engineering in Medicine and Biology Magazine, IEEE, vol. 21, pp. 42 – 57, Jan.- Feb. 2002
8. S. S. Mehta et al. "Computer-aided interpretation of ECG for diagnostics", Int. Journal of System Science, 43-58, 1996.